

Thesis/
Reports
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SEED SELECTION FOR NEBRASKA PLANTING

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Seed Selection for Nebraska Planting.

by

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EXPERIMENT STATION

The Problem

Seriousness of the Pine Tip-Moth:

For the past 10 or 12 years a tip-moth which appears to be Rhyacionia frustrana bushnelli, a variety of the eastern tip-moth (genus formerly called Evetria), has been steadily gaining in numbers in the pine plantations on the Bessey Division of the Nebraska National Forest, where it has spread almost as rapidly as new plantations are formed, and for a number of years greatly retards the height growth of the young pines. Side branches are affected as much, if not more than the leader, and their almost universal curtailment gives to yellow pines a narrow, cylindrical form which is quite unnatural, while the other species, which recover more readily by side buds or adventitious buds* called into play after the injury, the tendency to assume a bushy, much-branched appearance.

Undoubtedly, the western yellow pine is most seriously injured, not because the insect has any special preference for it, but because of its own sluggish character and inability to recover its losses by making new shoots. Norway pine is injured as badly, but there is relatively little of it in the plantations. Jack and Scotch pines probably receive as many injuries per tree, but show the effects much less seriously. Austrian pine is practically, if not wholly, immune.

The plantations on the Niobrara Division have also been hit by this insect, but on the whole not as heavily.

* Counts made by Dr. Graham of the Bureau of Entomology about August 1, 1926, show that Scotch pine has this power more fully, and yellow pine less fully, than the other species and indicate considerable individual variations which might be important in selection.

On attaining heights of 10-12 feet practically all trees begin to escape injury to the leaders, though the side branches may continue to feet it. As the trees, especially those of yellow pine, have become such compact masses of foliage, on short, stout stems, while their growth is being held back, it is believed that they are enabled to store considerable quantities of reserve food, and to establish their roots deeply in the soil. At any rate, when "released" by escape of the tips, they grow in height very rapidly. This is especially noticeable in a plantation of Norway pine which has been hard hit for many years, but in which, during the past two seasons, a good many leaders have escaped. Such being the case, the permanent injury to the tree may not be as great as it appears during the early stages. The main stem is usually distorted only to a minor extent by the turning-up of a lateral, and such distortions will be scarcely noticeable, when the stems attain diameters of 8-10 inches.

Growth in the aggregate is, however, probably retarded to the extent that green tissue is destroyed by the insects and prevented from functioning in food-building. For this reason every reasonable effort should be made, as is now being done by the Office of Forest Entomology, U. S. D. A., to place the insect under the same control of parasites as apparently exists in natural stands of western yellow pine throughout the Nebraska region, and thereby to limit it to a nominal amount of damage.

Seriousness of the Gall-rust:

Somewhat similarly, a gall-rust, Peridermium harknessii* has attacked the western yellow pine in the Bessey plantations, and some 4 or 5 years ago

* Mycologists are apparently undecided, as yet, as to whether this is the correct name and whether a similar form in Colorado is the same species.

its occurrence was noted so frequently that considerable alarm was felt and much effort was expended in trimming-off the limbs which carried the gall. This has be no means eradicated it, and there is probably no feasible means by which it can be completely eliminated from trees susceptible to it. However, we seriously question whether artificial means to remove it can be justified, considering the negligible damage which it does. As immunity to the spores is probably in some degree, at least, a function of bark thickness, the leader grows in thickness as well as length more rapidly than the side branches, and a vertical surface of course offers less opportunity for the spores to rest, the leaders and vertical stems are hit comparatively infrequently. When either branches or stems develop a gall they usually die, though occasionally "circulation" is maintained through the hypertrophied tissue and eventually the large gall is overgrown nearly completely by sound tissue, while leaving a "cat-face" or "canker" on one side.

Essentially the same disease occurs in lodgepole pine, occasionally in virulent form, but usually only causing mechanical weakness of the stem of an occasional tree. So far as the gall on limbs is concerned, it may be thought of as merely hastening the pruning process, as it is not believed that the mycelia of the fungus ever ramify and cause outbreaks in new spots.

Occasionally a tree is so susceptible to this disease and gathers so many galls as to be killed outright, and in view of this possibility, as well as the weakening of occasional trees which may be attacked on the stem, the disease should, of course, be stamped out if that can be done at reasonable cost. But this is not a matter for serious alarm as one "threatening" the success of the Nebraska plantations.

This gall-rust has so far appeared in numbers only on the yellow pine, though an occasional Scotch pine has it, and possibly other species also. It is to be thought of as essentially a yellow pine disease.

Relative Value of the Species in Nebraska:

There can be scarcely any doubt but that western yellow pine is the best species that can be planted in the Nebraska sandhills, because it is the species native to the region and soil type. It occurs in all directions from the Bessey Division, except possibly due south, either on sandhills or on the Arikaree sandstone in situ, from which the sand of the hills is assumed to be derived. While, in all similar situations, seldom making a tree much over 50 feet high, it may rather frequently attain diameters of 24-30 inches. The important point is that there exist strains of this species thoroughly adapted to the climate and soil of the region. Such can certainly not be said of any exotic, nor even of Jack or Norway pine from the Lake States.

Of other species, Austrian pine would naturally be chosen first, in the present circumstances, because of its practically complete freedom from the tip-moth. Because of this, some beautiful clean specimens have already developed. But even with the tip-moth injury, yellow pine outgrows it. The tree is very sluggish in early life and this leads to heavy losses during the establishment, as well as slow growth. What it might eventually amount to on so light a soil is, of course, problematical. Its development on loess soil in eastern Nebraska is no criterion whatever. Austrian pine can not be planted except at excessive cost.

Scotch pine is probably the second choice, provided a strain a good, straight stem-form can be developed. As early plantations of this species

are already bearing seed, the possibility of this is not remote. We would point out at this juncture the desirability of selecting seed only from trees of good form, and carefully avoiding the few individuals carrying Peridermium. (See also general recommendations concerning seed areas). Failure to collect seed from the bushy, short trees can not seriously retard progress. In this species, with its many varieties, quality is to be considered paramount, perhaps more than with any of the others.

So far, the promise of Scotch pine is good, but we can not avoid a reluctance to recommend it unreservedly for conditions so far removed from those of its native habitat. It is believed that no harm could be done, and possibly much good might result, from scattering the available Scotch pine of known origin, through the yellow pine plantations. Mixtures are good, on general principles.

Jack pine, while forming a quick cover has, we believe, already served its purpose of demonstrating the possibility of tree-growing in the sandhills. For windbreak planting by settlers it is probably the most satisfactory stock that can be set out. The majority of these individual plantations will never be a factor in timber-production. For government use and for an occasional, more ambitious private planting, we believe a timber species should be selected. Jack pine in the Nebraska sandhills will never be more than it is on the poorest sands of the Lake States, - a bushy cover of very low economic value. As funds for Nebraska planting are likely to decrease rather than increase, we believe the more conservative policy should be followed of planting for end results rather than immediate showing, and this species should be largely done away with.

Norway pine, when once under way, may prove as good a species as western yellow, but the probabilities are all against its proving well adapted climatically, because of winter conditions very different from those to which it is accustomed; it is very seriously retarded by the tip-moth, and, we believe the experience has been that it is not as easily raised or planted as yellow, jack or Scotch pine.

Evidence on the Effect of Seed Source for Yellow Pine:

The present study had its inception in the belief that the choice of seed is a very important item in the successful introduction of any plant into a new habitat, and that this selection should extend not only to the region offering the stock best adapted by reason of similarity of climate and soil, but also to the individual tree showing the greatest promise of resistance to the enemies which now beset the Nebraska plantations. It may almost be stated as an axiom that the severity of injuries, while in some cases varying with the individual, is in general inversely proportionate to the degree of adaptation of the strain to its environment, new or old. Therefore, in considering such a matter as the tip-moth injury, it is possible that individual trees may show a high degree of resistance or immunity; more probable, under the circumstances, that the strain best suited to the physical conditions and therefore making the most vigorous growth, will escape with the least proportionate injury.

For a number of years, tests have been under way to show, broadly, the region from which seed might best be taken for the Halsey plantations. If they have been inconclusive, as measured by early survival and growth, it is probably because only the general region of seed-collection was known, and

nothing as to the characters of the parent trees. However, all recent experience has led locally to the belief that seed from the Black Hills is preferable to Colorado yellow pine, and this is logical, since the climate of the Black Hills partakes of the nature of the plains climate fully as much if not more than it resembles the mountain climate. There is, however, no similarity between Nebraska and Black Hills soils.

The best evidence so far obtainable is vague and scarcely more than a "hunch". The first yellow pine, planted on the Bessey Division* in 1904, was a 1-year seedling stock from seed collected in 1902 in northwestern Nebraska. In 1905, there were available in the nursery 1-year seedlings from a large collection of New Mexico seed made in the fall of 1903. In 1906, 2-year seedlings of this source were wholly used, and on a large scale. This planting was anything but successful. In 1907, only a few hundred yellow pine were planted. In 1908, some 48,000 2-1, 2-0, and 3-0 trees were planted, the latter two groups being shown on the records as from New Mexico seed **, although there was undoubtedly in the nursery at that time the first 2-0 stock grown from the 1905 collection of Pine Ridge and Black Hills (Pringle) seed. (Seed-collecting reports in the Nebraska files indicate that 90 percent of the entire fall's collection was from the Black Hills. We have been unable to find seed-distribution records showing where the collections were used, but activity in the Black Hills at that time probably consumed most of the local seed.

* According to a letter from Chas. A. Scott, of June, 1926. These are said to have done very well, and were scattered over quite a large area.

** It is believed this record is in error, the 2-0 and not the 2-1 stock being from the Nebraska seed collection.

The year 1909 may be said to mark the beginning of successful planting of yellow pine. Some 132 M were set out. There were 3-1 trees from the New Mexico seed-collection, but the bulk were 2-1 trees of the 1905 seed-collection. The records designate all of this seed used at Halsey as "Glenn, Nebr.", but we doubt not that some of the Black Hills seed was used indiscriminately under this name. There was also in use about this time some seed designated "Sioux Forest", but whether this was actually from the Sioux Forest or from Sioux County, Nebraska is something of a question.

We have now, two lessons to be pointed out. First, some of the few surviving trees of the oldest planting (northwestern Nebraska seed) are outstanding for their size and under way before tip-moths became abundant, but their present vigor indicates that they are also well adapted to the climate and soil.* Photos attached of the "Graveyard" area, long outstanding for its clump of healthy trees, bear testimony to this. (See Plate I)

* The senior author clearly remembers being shown trees of this planting, on several areas, by Mast, during a visit of Zon in 1909. On steep north slopes, the trees were still struggling to raise their heads above the grass, but were remarkable for their clean, healthy appearance, whereas it is a well-known fact that in many of the latter plantations, this long struggle often resulted in a yellowed tree of unhealthy appearance. It is believed a good many of our impressions of yellow pine behavior on the Nebraska have been formed from observation of the poorly-adapted New Mexico stock, and more recently Colorado stock.

Secondly, the beginning of successful planting in 1909 coincides with the elimination of the stock from the New Mexico seed and the use of Pine Ridge or Black Hills stock. Credit has been given to the systematic experiments of 1909, and to gradually improving nursery practice for the steady gain in effectiveness of the planting since that time. Both have had some effect, but the main credit belongs to the use of stock of suitable origin. It would be very difficult to obtain extensive and accurate information on, or proof of, this. For a clear example, however, we may turn to the small plots of Block A, representing a portion of the 1909 experiments. In this group plots 10, 11, and 12, respectively, were planted with 3-1, 2-1, and 1-1 transplants of yellow pine. Although the difference was not noted at the time, nursery records show that the 3-1 stock was from New Mexico seed, while the 1-1 stock and 2-1 lots were from seed collected in the northwestern part of Nebraska. In the count of the fall of 1909 the 3-1 stock showed 88 percent. This experiment was dropped rather early, and records of later actual counts can not be located, although there is a hint in a general statement of later date that the 3-1 stock had lost its lead. This is relatively unimportant in contrast to present conditions. Plot 10 is surrounded on the south, east and north by trees of the Nebraska origin, and the difference in appearance is so outstanding as to catch the eye immediately. The trees of New Mexico origin are scarcely more than half as high as the others, and the difference is due to in no small part to the continual "cropping" of the unsuitable stock by the tip-moth. (To make this record more complete the Supervisor is requested to measure the trees of Plot 10 in connection with the next measurements of Fp-101 (f), test of sites. The situation is such that a photograph could not be made to show the contrasts.)

This is, of course, represents an extreme case so far as differences in seed origin are concerned, but it requires extremes to clarify so subtle a point.

During recent years the bulk of yellow pine seed used on the Nebraska has come from the Black Hills, but there have been various minor collections from Colorado, and some of the New Mexico seed entered into plantations as late as 1912. While accurate comparisons are not available, it is the opinion of Supervisor Higgens that the Black Hills seed has produced the more satisfactory stock and results, in every sense.

Other Evidence on the Value of Local Seed:

If other evidence is needed that seed of comparatively local origin and partial or complete adaptation to the climatic conditions, it to be preferred, it is only necessary to point to stock at present in the nursery, Scotch pine 2-year seedlings from seed collected from the earlier plantations are nearly twice as large as Scotch pine from a central European source. (It is believed that the former was, at least in part, seed of the superior Riga variety). Austrian pine seed collected near Lincoln, Nebraska, has produced stock far more satisfactory than any other Austrian pine so far grown.

Survey of Native Pine in Nebraska and South Dakota

It being conceded that seed collected near the Nebraska Forest offers greatest promise of resistance to pests because of its climatic adaption and consequent more healthy condition in this environment, the question arises, - to what extent have individuals or strains of the native pine developed immunity of especially high resistance to the pests which especially concern us, the tip-moth and gall-rust? In considering this question it should be clearly kept in mind that the absence of a pest from a locality does not establish the immunity of the entire strain of that locality. Such absence may denote merely favorable soil conditions, just as the mistletoe of yellow pine appears and disappears fairly regularly, with poor and good soils. Only if we find the pest or pests absent from individuals or groups in a locality not entirely free from them, may we presume a degree of immunity and a stock of absolute value.

In the hope then, of noting the prevalence of the two important pests in the natural range of yellow pine, and of establishing the facts as to whether any degree of immunity to them had been developed, and also with a view to gauging anew the economic possibilities of yellow pine under soil and climatic conditions approaching those of the Nebraska Forest, and extensive survey was made by the writers from June 20 to July 6, 1926. In the course of this survey, two or three trees especially attractive for seed-collecting purposes were marked in each of several localities, 32 in all being so designated. Since each of these trees represents superior development in its locality, we may gain some idea as to the relative values of the several localities by plotting height on age for each sample tree, as in the attached diagram. This does not, however, bring out any clear differences,

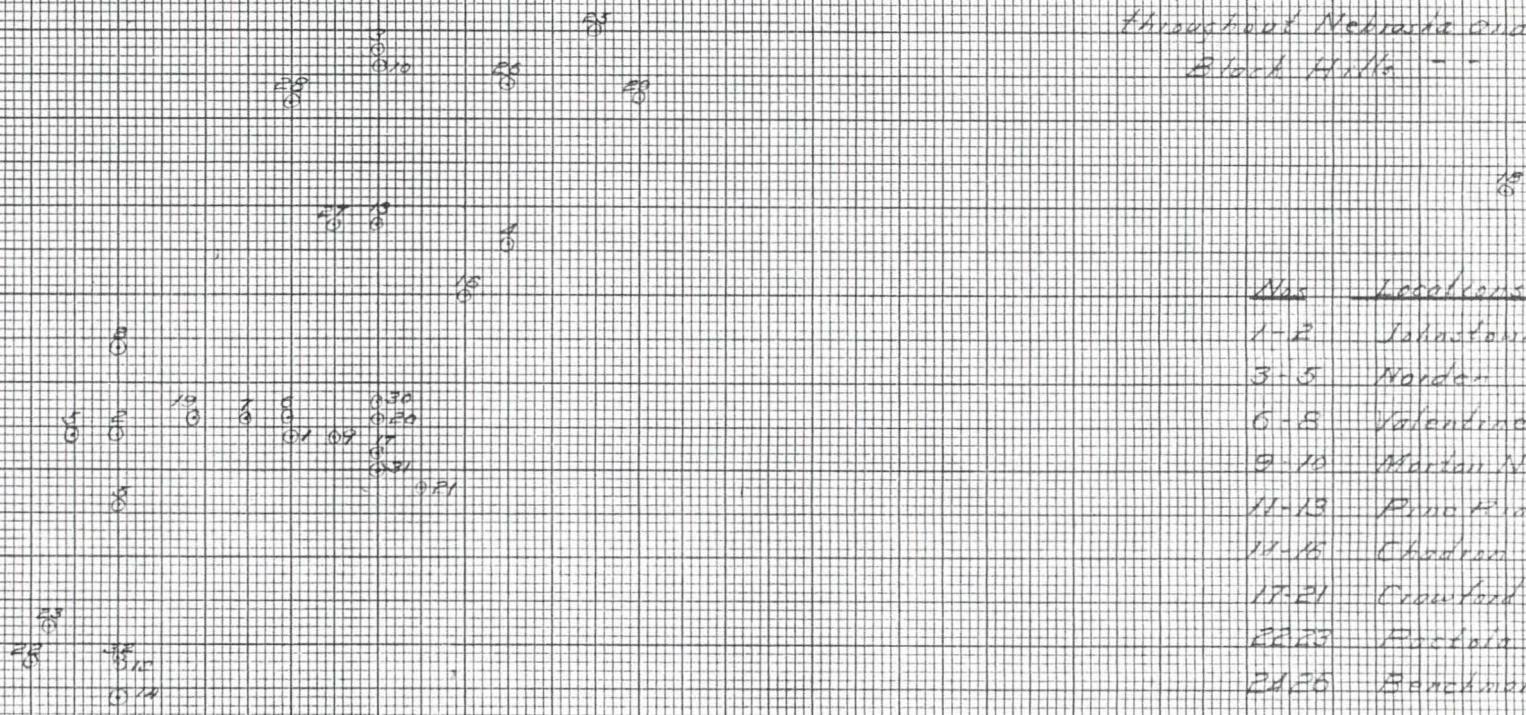
except possibly to establish the fact that the timber examined in the vicinity of Crawford was about the poorest of any. Probably the Black Hills localities as a whole run to better heights than the Nebraska and Pine Ridge localities, but this may easily be due to the higher average density of stands in the Black Hills.

Soil and Climatic Uniformity:

It goes without saying, naturally, that the climatic conditions of the nearest localities in which pine grows must be very similar to those at Halsey. This whole subject may well be covered by pointing out that from Custer County on the southeast to Sioux in the northwest corner of the State, with a gradual rise in elevation, there is a decrease in precipitation, from about 23 inches to about 16 inches,* and a similar decrease in mean temperatures annually which partly compensates (by lower evaporation) the lack of moisture. With the sharper rise in the Black Hills, temperatures drop still further, while precipitation again increases, being about 22 inches at Custer and over 25" in the higher northern portion of the Hills.

All of these localities, however, have a common climate on the sense of showing increasing precipitation through the spring months, held at a high point through August in the eastern and through June or July in the extreme western portion. This is a character which very markedly affects the adaptability of trees to a region, for if trees are habituated to relatively dry spring, it is probable that they will show a sluggish character at that season. Seeds will tend to show similar responses in their time and rate of germination.

* (The "Atlas of American Agriculture", II Climate, 1922, shows a zone of less than 15 inches precipitation extending northward from Halsey to the west of Valentine and into North Dakota, but we can find nothing in the more recently published Climatological Data of the Weather Bureau to justify this and are convinced that none of the region with which we are concerned, received less than 16 inches annually.)



FS - 101 (d) Nebraska

Height of Age of Superior Trees
throughout Nebraska and the
Great Plains -

Nov 16001275

1-2	Johnstown
3-5	Norden
6-8	Valentino
9-10	Marian Nursery
11-13	Pine Ridge, S.D.
14-15	Chadron
17-21	Crawford
22-23	Factoain
24-26	Benchmark
27-29	Perryton
30-32	Trust

Persons Total Age - 49225

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

Of far more importance than slight climatic variations is the fact that the pine in this entire region, exclusive of the Black Hills, enjoys the same type of soil, being either of the beds of Arikaree sandstone or on the wind-blown sand from these beds. The writers were under the impression that the entire southeastern portion of the sandhills represented sand carried for a great distance from the beds in northern and northwestern Nebraska. Such is probably not the case, for outcrops of what appear to be very soft beds of Arikaree in place occur on the Dismal River, on the Niobrara, and in Custer County where not covered over by the loess deposit typical of all eastern Nebraska.

While then, these soils may vary considerably in physical composition, the "body" increasing with proximity to the original beds, and being poorest in the roughest type of sandhills, the chemical nature of the soil is probably essentially the same throughout. Certain portions of the Arikaree are probably a little more calcareous than others, and the proportion of clay varies from practically nothing to a large percentage in very localized beds. The following table shows the extremes of composition likely to be encountered, with the exception of washed-in beds of clay.

Southeastern Extension of the Pine:

The early writings of the late Dr. Chas. E. Bessey, regarding the sandhills and their possibilities for pine, contained mention of native yellow pine near Broken Bow, Nebraska. Supervisor Higgins had also learned of its occurrence in Loup County, and the writers, accompanied by Supervisor Higgins, visited these groves to note the character of development under these climatic extremes. The Custer County pine was readily found in the escarpments of a high area northwest of Callaway, known locally as "Pine Canon", a very

Table I.

Soil Description	Composition as shown by mechanical analysis									
	:Percen-:	:								
	:tage of:	: Fine :Coarse : Med-: Fine : Very : : :								
	:soluble:	pH	:gravel	:gravel	: hum	: sand	: fine	:Silt:	Clay:	Desig-:
	:matter :				:sand :			: sand :		: nation:
			%	%	%	%	%	%	%	%
White "clay" on bluffs of Dis- mal River, apparently Arikaree <u>in situ.</u> Not calcareous.	.056	7.0	0.0	0.2	0.5	3.0	40.0	55.4	0.9	Silt loam
Yellowish sand from cliff in Pine Canon, apparently Arik- aree <u>in situ.</u>	.036	7.0	0.0	0.6	8.4	26.1	54.4	8.6	1.9	Very fine sand
Same, as washed to foot of slope, with humus	.074	7.5	0.0	0.8	3.2	13.5	43.8	34.3	4.4	Fine sandy loam
Cleanest windblown sand, from depth of 7 feet, at "Grave- yard" in Halsey plantations	.040	6.5	0.2	14.8	32.0	25.6	27.1	0.3	T	Sand

picturesque spot in a prairie land. The Loup County pine was similarly found in an eroded high divide between the Middle and North Loup Rivers about 8 miles northwest of Sargent. This area is called "Cheeseborough Canon". According to A. H. Exley, son of the man who settled the place over 40 years ago, the pines were never numerous in this canon, which contains a wonderful display of red cedars. A few trees 24" D.B.H. or better, were, however, cut in the early days. Scarcely more than a dozen trees were seen in a hasty examination, but those growing on a northeast slope among other trees were tall and straight, though rather thin-crowned. (See Plate IV and V.).

Pine was probably more abundant in Pine Canon, and a local resident stated that a sawmill was located there 45-50 years ago. There is no stump evidence as to size or number. There is a considerable present grove of young trees, which apparently would extend itself without difficulty were it not for grazing. There are several small scattered groups of trees in separated gullies. Cedar occurs with this pine but not so abundantly as in Cheeseborough. (See Plates II and III.)

At this point there was first noted, a few form of tip-moth, which, to distinguish it from the moth occurring at Halsey, we will hereafter denote merely as "pitch-top" until the insect itself has been identified. This insect has not been noted at Halsey, but occurs almost everywhere in Nebraska on the native pine, including that on the Niobrara Division of the Forest. It is apparently much less injurious than the tip-moth, though very abundant in some places. It mines a comparatively small section of the new growth.

Two trees were marked and measured in this canon more as a matter of record and comparison than because of absolute desirability. No. 1 is not absolutely free of Peridermium. No. 2 is clean but does not appear to be a cone-bearer.

Proceeding toward Norden from the Niobrara bridge, trees were marked 2.4, 4.4, and 5.05 miles respectively from the bridge. These (3, 4, and 5) are all good clean trees, No. 3 being notably free of tip-moth and pitch-tip. All will bear cones in 1926, apparently of good quality. Each of these trees is in the midst of a group of good cone-bearers, and many other clean trees can probably be found, both at these points and on the east side of the road where there are even more extensive stands.

This locality is recommended for seed collecting in 1926. Absolute freedom from Peridermium should be demanded of all seed trees. The tendency toward weakness in the crosses can also be determined if there is young growth around the seed trees, since Peridermium is everywhere to be found. Seed trees can be avoided not only on their own appearance but on the evidence of their progeny.

Valentine:

The Minneachaduza Canon at Valentine is not an especially good locality as the trees are mostly young, rather scattered and of poor quality. Pitch-tip is abundant and apparently does a good deal of damage, few of the trees being clean-limbed. Peridermium is present. Trees 6, 7, and 8 were designated. Tree 6 is not an especially good specimen, but bears 1926 cones and several other equally good trees can probably be found in its vicinity.

Tree 7 is of doubtful value since it has had on its branches a couple of rust-galls which, however, it overcame. Tree 8 is a very fine specimen for this locality, and its good crop for 1926 should be all means be collected. This tree is at the top of the hill, leaving the Minneachaduza on the Valentine-Crookston road.

Niobrara Division of the Forest:

Accompanied by Ranger Lord, the three individuals and the group from which he collected cones on the south rim of Niobrara Canon in 1925 were examined. None of these trees was found to be of especially desirable form, although No. 3, as he stated, was comparatively free of pitch-tip.

Trees 9 and 10 were marked in the same locality. No. 9 is comparatively free of pitch-tip, and free of Peridermium, which was not seen at all in its locality. No. 10, a canon rather than a rim specimen, is quite an outstanding tree and bears a heavy crop of 1926 cones. This tree, however, is heavily infested with a leaf-scale which is of comparatively rare occurrence, and if the cones are collected, as seems desirable, it is very important that the cones immediately after picking can be given a dip which will guarantee the non-transference of this scale to the seed and possibly to the Halsey plantations. Its occurrence here does not seem to be of any significance, it being observed in isolated spots on a number of occasions.

On the planted stock at Lookout Ranger Station the tip-moth was observed in almost the same abundance as at Halsey, some pitch-tip was seen, but, so far as we can recall, no Peridermium.

Pine Ridge in South Dakota:

Primarily to check Bates' recollection of timber of good stature in the Pine Ridge canons on the South Dakota side, the Indian Reservation was entered from Gordon, Nebraska, and the localities of Porcupine, Brennan, and Manderson were visited. All of this locality appears relatively free of pitch-tip and Peridermium, but as elsewhere, there is no complete absence of the tip-moth.

Tree No. 11 is the best 100-foot tree to be found in a canon about 3 miles northeast of Porcupine. It probably represents about the maximum development for this type, presumably because of better-than-average soil conditions. It bears only a few cones for 1926, and like all the cones from here westward, these are weeviled and probably will be of no value.

Tree No. 12 occurs on the top of an exposed promontory and well-known landmark known as "Porcupine Butte". Although a tree of small stature, it is outstanding among its fellows. It will bear no cones in 1926.

Tree No. 13, between Brennan and Manderson, is an excellent specimen and several young trees in its vicinity probably bear evidence of this quality. It is practically free of pitch-tip. There are no cones at present.

The Pine Ridge region shows nothing remarkable considering the quality of the soil, and is not an especially good area because there is so little Peridermium that immunity can not be established with certainty. Good form and stature are, however, sometimes reached in the canons with a rainfall of not over 18 inches.

Chadron:

There is very considerable area of pine of the escarpment of the White River basin south of Chadron, and the existance of the State Park within this

area may possibly offer opportunities for special seed collecting which would not be available where the trees were liable to cutting. However, none of the trees marked were known to be within the Park boundaries. The soil is poor (Arikaree somewhat calcareous), Peridermium is very abundant, and pitch-tip nearly as abundant as at any place visited. Tip-moth is sparingly present, there being relatively little new work. Plate VI, Fig. 1 and photo of Tree 15 illustrate the virulence of the Peridermium and the possibility of securing complete immunity to it where the evidence is so clear. This is considered one of the best possible localities for seed collecting, for this reason.

The main Rim, or edge of prairie is about 12 miles south of Chadron on the Alliance road, but beyond this there are shallow gullies extending back considerable distances and cut through the heavy upland soil to the Arikaree. In one of these there is a solitary pine 2 miles back from the main stands and another 4 miles back (both visible from the highway, - east). The first of these is a Peridermium tree, while the second, or more distant (No. 14) is free of this disease and only moderately hit by pitch-tip. Since this tree is 2 miles from the nearest pollinator, it is likely to be largely "selfed" and its seed present interesting possibilities. It is a short tree but not a bad specimen considering the circumstances. It will probably have a considerable crop of cones in 1927.

Tree 15 is just below the escarpment and was selected because of its complete freedom from Peridermium while growing in immediate contact with the disease. This tree is free of tip-moth and relatively so of pitch-tip. There are numbers of other good clean trees in the vicinity which may furnish the bulk of the pollen, and probably plenty of other young trees from which cones might be collected. There will, however, be no cones before 1928.

Tree 16 is an equally good tree in a good locality only 6.5 miles from Chadron. Possibly in 1928, a very good collection of seed could be made from this tree and some equally good neighbors.

At a point 2.6 miles south of the northern entrance to the State Park and west of the main road, is an area of pine of peculiar appearance and vigorous growth (one tree age 60, height 55 feet, D.B.H. 15.5"). Although no sample trees were marked here, because of lack of time to make thorough examination for Peridermium, this group should be further investigated. These trees are characterized by rather smooth blackish bark and their clear boles give them an appearance suggestive of white pine. This may, however, represent nothing more than a pocket of unusually good soil.

Crawford (west and south):

An area near the Harrison road and another not far off the Belmont road were examined to obtain a cross-section of conditions near Crawford (west and south, respectively). This is more distinctly the "Pine Ridge" type and was rather disappointing. We can not see that it has as many advantages as Chadron for large-scale collecting. The timber is more scattered and trees of good development are scarce, in spite of the fact that Peridermium, tip-moth, and pitch-tip are also relatively scarce. All of the sample trees except 19 (in deep soil at foot of slope) are below average stature for their ages.

Nos. 17 and 18, and 19 are fairly close together in the area west of Ft. Robinson. No. 17 is in the center of a close clump, but has outstripped all the trees of same age around it. No. 18 is a rather large, north-slope specimen. No. 19 is a tree of very unusual vigor, open and clean-limbed. All of these trees are good bearers, but no crops are in prospect.

Nos. 20 and 21 are nearly identical, standing close together in the area south of Crawford. There are others equally good near them. They were selected as representatives of poor site conditions, sandy enough to make Yucca a characteristic plant. Their average height of 36 feet in 72 years seems too poor even for the sandhills. These two trees may bear a few cones in 1927.

Black Hills at Pactola and Benchmark (Schist):

Accompanied by Supervisor Duthie, and at Pactola by Ranger Webber, two young trees were marked on the Deer Creek drainage where Ranger Webber had reported a considerable tip-moth infestation. There probably is an unusual amount of tip-moth at this spot, in comparison with the Black Hills in general, but nothing unusual in comparison with most of the Nebraska areas visited. Peridermium is also present and Trees 22 and 23 were selected because of good vigor and freedom from this disease. Neither is a cone-bearer as yet but should be in a few years.

At Benchmark somewhat older trees were selected in an area where the stand as a whole is young and of good size for hand-picking. Trees 24, 25, and 26 are of about equal quality and were selected for freedom from Peridermium. However, it was noted on many trees in this locality, by the lower dead limbs, that the rust had affected them when young though they are clean now. Unless, therefore, all the lower limbs have been retained it will be rather difficult here to establish the immunity of individuals.

These trees, in the 90-year class, and growing on a schist soil, show little superiority over some Nebraska trees, for example Tree No. 3 at Norden. They will not bear cones in 1926 or 1927, although the locality may produce a few in 1927.

Black Hills at Pringle (Limestone):

Special interest was felt in this locality because of the 1905 seed collection being made here, although it is doubtful how much of this seed was used on the Nebraska. It is good for seed collecting because nearly all the timber is comparatively young. The entire locality is limestone, producing apparently a grayish soil of very good quality.

Trees 27, 28, and 29 are all trees of excellent quality, in the presence of some Peridermium and tip-moth. There are an unusual number of fine specimens nearby, and the area is only a stone's throw from the Pringle Ranger Station. No cones are in prospect for 1926 or 1927, quite a large crop having been borne in 1925.

Lusk, Wyoming:

The western extension of the Pine Ridge is again crossed 14 miles northeast of Lusk on the Edgemont road. Sample trees 30, 31, and 32 have nothing unusual to recommend them, but show that heights here are below average. Nos. 31, and 32 are perfectly clean, while No. 30 has a little pitch-tip, not abundant in this locality. A very little Peridermium was seen, and some tip-moth on small trees.

Conclusions and Recommendations

From this survey of the native pine in the areas most likely to furnish seed adapted to Nebraska conditions, and certain other facts, the following conclusions may be drawn:

1. The pine tip-moth doing so much damage to yellow pine plantations on the Nebraska, is everywhere present in the native pine, more abundant in some places than in others but nowhere so abundant as at Halsey. The fact that it is everywhere present, and that perhaps a majority of young trees harbor it, yet these develop in essentially normal form, seems to indicate that the insect is held down by parasites. In other words, the insect has outgrown its parasites at Halsey, possibly because of the extensive, solid areas of young trees made available to it. The direct thing to do is to breed its parasites, as is at present being done under the wise direction of the Bureau of Entomology.

2. Individual or group immunity to this tip-moth or to "pitch-tip" has not been indicated, and in the nature of the case seems unlikely to occur. So far as it can be combatted by selection, then, it must be through selection of thoroughly adapted trees which will make vigorous growth in spite of the tip-moth and quickly reach a height where the insect does not operate. (The suggestion from Dr. Graham that the ability to produce adventitious buds is a valuable individual quality, is well worth considering).

3. Pitch-tip is a less serious pest not yet injuring the plantations but never-the-less one that should be understood. Its activities are hardly less universal than those of the tip-moth, but seem to be more definitely restricted by climatic conditions, a short growing season apparently being sufficient to prevent its development.

4. Peridermium similar to that occurring at Halsey is found almost everywhere in the Nebraska and South Dakota pine, apparently being least abundant on the best soils. It occasionally kills trees. Some trees seem to be absolutely immune to it. Such being the case, great care should be

exercised never to take seed from trees which at any stage of life have had a rust-gall. If this is avoided, a fair proportion of the progeny should show complete immunity. A small amount of Peridermium on a tree certainly does not keep it from bearing seed, so there is always the danger that susceptible trees may prove attractive to the cone-collector.

5. The vicinities of Norden and Chadron, of those visited, appear best suited to the collection of seed for the Nebraska, both because of their physical conditions and good stands, and because there is sufficient Peridermium present so that the immunity of individual seed trees, or lack of it, may be quite well established in each instance.

The following recommendations are made:

1. That current experiments designed to show the value of seed from different sources, so far as these are accompanied by an knowledge of the character of the parent trees and what may be expected from them, be continued to a logical conclusion. This includes the tests started in the nursery in 1924 and the still more comprehensive series of 1926.

2. That seed for the Nebraska planting be collected, with a view to the questions of immunity and vigor that have been discussed, at least on an experimental scale from the special trees that have been selected, or others like them, and preferably on a scale large enough to make a broad comparison between seed from Black Hills sources and that from the near neighborhood of the Nebraska. Seed collected on an experimental scale should be handled in individual tree lots, carried through the nursery with no special treatment except segregation, and planted in marked rows of the "seeded area" described hereafter. This work should be started by collections near Norden and Valentine in 1926, taking advantage of the good seed-crops.

3. That no Colorado or other "foreign" seed of yellow pine be used in this planting, the Black Hills being the most remote source to be considered at present.

4. That "seed areas" be developed in existing plantations. An area should be set aside which is as remote as possible from other yellow pine plantations and where the trees are promising, the idea being, of course, to reduce to a minimum pollination from unknown sources. In this area only the most perfect specimens should be allowed to develop and these should be given ample room to develop early into seed-bearers. There should be no trimming or other such artificial treatment to "favor" all or a part of the plantation, but as the trees become larger only the best specimens, - from every standpoint, - should be left. Eventually every individual which has shown any weakness toward Peridermium should be ruthlessly weeded out, but this should not be done hastily since it is desirable to expose every tree to the disease; and trees which seem especially attractive to the tip-moth should be similarly eliminated. A similar procedure can be followed with Scotch pine and other species.*

5. A new area, which can be more completely segregated from other yellow pine* than is probably possible with any of existing plantations, should be set aside as the seat of all future planting of special "breeding" lots. The experiments will doubtless contain, for comparative purposes, groups which are undesirable, but these can readily be eliminated after they have served their experimental purpose and before they become seed or pollen-bearers. This area should be consciously developed as the growing-place of the best specimens that can be brought together from many sources. The value

* There is no reason why the several species should have separate "seed areas" in future plans, and there will be some advantages in having them occur in proximity to each other.

of the individual trees under these conditions will be proven by their development before they reach seed-bearing age, and only the best need be kept. If a variety of strains are thus ~~brought~~^{brought} into proximity, there will eventually be, without any special effort, a multitude of crosses which will breed some very strong strains. Possibly there will be no greater value in the arrangement than the very general crossing of unrelated, and generally strong strains. If the segregation of this group is really at all complete, it may be desirable after a few years to attempt to introduce Peridermium artificially, in case it has not appeared on any trees, but we doubt not that some of the spores will be brought in, so that this will be unnecessary.

Naturally, for the rapid development of these trees the best possible site will be chosen. We would suggest one of the flat or gently sloping up-lands rather than rough hills, steep slopes or bottom situations. The area should be so laid out that individual lots added from time to time can be planted one or two rows extending across ~~all~~ of the sites represented, normal to the general contours.

6. All phases of this work should be given the joint attention of planting and Research men so far as possible, the exact division of the work at any time, naturally, having to be determined by the circumstances.

7. In the routine planting program of the Nebraska the entire question of seed-sources should be given more attention than it has been given in the past, more carefully study by the entire organization, better records, Relatively, it can be no more profitable to grow mongrel trees than mongrel animals.

Respectfully submitted,

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Note: The Nebraska and Rocky Mountain Experimental Station copies of this report are accompanied by Forms 279 describing each sample tree, Nos. 1-32, with photos attached for 21 of the trees. The District Forester's copy is accompanied by photos only of the 21 sample trees, and the Forester's copy by photo descriptions without the prints.